LID IMPLICATION FOR URBAN RUNOFF MANAGEMENT IN RESPONSE TO CLIMATE CHANGE IMPACTS

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Urban runoff management

- Previous work
  - *Journal of hydrology*
  - *Science of the Total Environment*

- Current research
  - Climate change impact on urban runoff management

**Question 1:** Does the optimum solution based on the current situation work well for the possible future rainfall scenarios?

**Question 2:** Is it necessary to develop another approach which can consider all of the possible future scenarios together (multi-event optimization)?
<table>
<thead>
<tr>
<th>Traditional view</th>
<th>Methodology</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Drainage system design</td>
<td>• Update the design hydrograph</td>
<td></td>
</tr>
<tr>
<td>o Historical hydrologic data</td>
<td>• Use general circulation models (GCMs)</td>
<td></td>
</tr>
<tr>
<td>o Frequency analysis</td>
<td>• Downscaling methods</td>
<td></td>
</tr>
</tbody>
</table>

Climate change

• Alter the pattern (intensity and duration)

Develop a Simulation-Optimization model

International financiers redirect funding to climate change
https://www.developmentafrica.net
Analyzing climate change impacts on watershed runoff management

1- Data collection and processing
2- Rainfall-runoff model
3- Urban runoff management
4- Climate change impact modeling
5- Optimization model
Introduction

Methodology

Result
Low impact developments (LIDs)

Permeable pavement (PrPv)

Vegetative swale (VeS)

Infiltration trench (InTr)

Bio-retention cell (BRc)

https://nacto.org

http://www.missionengineersinc.com

https://ready.nola.gov/green-infrastructure

https://www.lid-stormwater.net/biolowres_specs
Climate change impact modeling

- **GCMs**: the mathematical coupled models which simulate the response of earth systems to changes in the greenhouse gases concentrations
- **CFM**: incorporate information of local observed rainfall
  - High resolution observational data
  - Regional-scale

### Climate change impact on the design rainfall

<table>
<thead>
<tr>
<th>Design rainfall</th>
<th>Observed rainfall</th>
<th>Future rainfall</th>
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<tbody>
<tr>
<td></td>
<td>Mean Value (mm)</td>
<td>Absolute</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min P</td>
</tr>
<tr>
<td>Scenario</td>
<td>S1*</td>
<td>S2</td>
</tr>
<tr>
<td>Mean</td>
<td>36.6</td>
<td>24.5</td>
</tr>
<tr>
<td>Difference (%)</td>
<td>0%</td>
<td>-33%</td>
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<tr>
<td>Maximum</td>
<td>S8</td>
<td>S9</td>
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<tr>
<td>Value (mm)</td>
<td>54.0</td>
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<tr>
<td>Difference (%)</td>
<td>0%</td>
<td>-30%</td>
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</table>

* Scenario
Optimization model

- Single objective function
- Genetic algorithm (MATLAB software)

Objective function:
- \( \text{Minimize } F(x) = [w_1 \times \text{Obj 1} + w_2 \times \text{Obj 2}] \)
- \( \text{Obj 1} = \frac{V(x) - V_{\text{min}}}{V_{\text{max}} - V_{\text{min}}} \), \( \text{Obj 2} = \frac{C(x) - C_{\text{min}}}{C_{\text{max}} - C_{\text{min}}} \)

- \( V \): runoff volume
- \( C \): implementation cost of LIDs
- \( w_1 = w_2 = 0.5 \)

- Decision variable: location and area of each LID (40)
- Constraints: maximum and minimum possible area of LIDs in each subcatchment
**Objective function**

- **Rainfall (mm/day)**
- **Volume (10^6 lit)**

- Objective function value

- Graph showing the relationship between volume and rainfall.
Question 1:
Does the optimum solution based on the current situation works well for the possible future rainfall scenarios?
**Question 2:**

Is it needed to develop another approach which can consider all of the possible future scenarios together (multi-event optimization)?

$$\text{Minimize } \sum_{s=1}^{s=14} F(x) = [w_1 \times Obj^1_s + w_2 \times Obj^2_s]$$

![Graph showing objective function values against rainfall (mm/day)]

- **Main:** 4.2084
- **Rainfall 1 Constant:** 4.1957
- **Rainfall 8 Constant:** 4.1764
- **OptimAll:** 4.1431

**Running time:** 14 times more
Conclusion

• Climate change can alter our final urban runoff management decisions (location and area of LID types)

• The significance and importance of the result change

• Based on the objective function definition
Thank you
Rapid urbanization
Unplanned development of lands
Population growth
Aged drainage systems
Climate change

Surface runoff management
Optimization result

S2 (24 mm/day)

S8 (54 mm/day)

S14 (90 mm/day)

(1. VeS  2. BRc  3. PrPv  4. InTr )

S1 (36.6)
Optimization result

(1. VeS  2. BRc  3. PrPv  4. InTr )
Optimization result

![Graph showing optimization results](image-url)
Total area: 19.77 km²
<table>
<thead>
<tr>
<th>Sub*</th>
<th>Area (hectare)</th>
<th>Width (m)</th>
<th>Slope (%)</th>
<th>Impv** (%)</th>
<th>Land Use***</th>
<th>Sub</th>
<th>Area (hectare)</th>
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Rainfall hyetograph (mean values)

Rainfall hyetograph (maximum values)
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<tr>
<th>Sub*</th>
<th>Total Runoff (mm)</th>
<th>Impv (%)**</th>
<th>Indicator***</th>
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